Creation of observables in reflection spectroscopy for next-generation instruments at the ELT

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Observation of telluric exoplanets is currently extremely challenging because of their small size (transit) and their low luminosity (emitted or reflected light). These limitations strongly reduce the signal-to-noise ratio and make the detection of atmospheric features particularly difficult. In this context, the Extremely Large Telescope (ELT) developed by ESO can be seen as a promising solution to combine high spectral and spatial resolution observations, thanks to its large collecting area and next-generation instruments currently under development (ANDES and PCS for the ELT, as well as RISTRETTO for the VLT). In particular, ANDES is expected to characterize for the first time the atmosphere of the temperate rocky planet Proxima b, with a resolving power of up to 100 000, enabling the detection of faint molecular signatures.

Such high-performance instruments require consistent modelling efforts to properly prepare future observations and to clarify the science cases of projects such as PCS. In this context, my work focuses on the generation of observables using a radiative transfer model: Pytmosph3r (Falco et al. 2022). Initially developed for transit spectroscopy, this model can also be applied to reflected light studies, providing new insights into the impact of atmospheric composition and structure on the reflected spectrum of exoplanets. By relying on high-quality opacity data (Chaverot et al. 2025), corresponding to a wide range of chemical compositions and thermodynamic conditions, we are able to explore a large portion of the parameter space relevant to telluric exoplanet atmospheres, from transparent N_2-dominated cases to more opaque CO_2-rich environments.

I will present preliminary results showing the impact of several key aspects : (i) the atmospheric composition, (ii) the stellar spectral type, with different maximum emission peaks and (iii) the spectral resolution.

The reflectivity of the atmosphere is primarily driven by chemical compositions, as different gas mixtures can lead to opposite climates. Molecules absorb in a wide range of spectral bands, therefore they do not share the same sensitivity to all stars. An atmosphere does not react in a same way to a redder M-dwarf’s infrared input than with a sun-like G-type star. Finally, quantifying the resolution effect on the loss of faint rays from either minor components or secondary absorption processes (as CIA), appears fundamental to link observations with the composition of the atmosphere. Considering these aspects is essential because each of them directly impacts the detectability and interpretation of atmospheric features. Their combined study will help place stronger constraints on the properties of temperate planets in the context of the search for habitable worlds